UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualifications:-

B.Eng. *M.Eng.*

Chemical Eng E879: Biochemical Reaction Engineering

COURSE CODE	:	**CENGE879**
UNIT VALUE	:	**0.50**
DATE	:	**07-MAY-04**
TIME	:	**10.00**
TIME ALLOWED	:	**3 Hours**

04-C0201-3-50

TURN OVER

Answer FOUR QUESTIONS. **Only the first four answers given will be marked.**
ALL questions carry a total of 25 MARKS each, distributed as shown [ ]

1.

This question concerns biocatalytic reactor kinetics.

a) Derive an expression (based on a mass balance) to describe the productivity of a continuous stirred tank reactor. [12]

b) Use the expression derived and graphical techniques, as appropriate, to explain why the continuous stirred tank reactor is rarely used in industrial operation. [8]

c) Under what circumstances might the continuous stirred tank reactor be used? [5]

2.

This question concerns the use of immobilised enzymes within porous particles as biocatalysts for the synthesis of fine chemicals.

a) What is the rationale for biocatalyst immobilisation? What disadvantages result from immobilisation? [5]

b) Describe in qualitative and quantitative terms what is meant by diffusional limitation in such immobilised biocatalysts. [6]

c) Describe a simple experimental test to establish whether there is internal diffusional limitation in a given system. [4]

d) Using expressions for the Effectiveness Factor, the Damkohler Number and the Thiele Modulus, describe how the diffusional limitations described in (b) can be overcome. [10]

3.

This question concerns substrate and product inhibition in industrial biocatalysis.

a) Describe qualitatively, and using graphs as appropriate, what is meant by substrate and product inhibition. [5]

b) What techniques (including biological and process related methods) are available to overcome these limitations to biocatalytic processes? [7]

c) Devise a table listing the key advantages and disadvantages of each technique in (b), taking into account the time to implement the technique and the degree of improvement which can be achieved. [13]

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4.

This question concerns the use of organic solvents in biocatalysis

a) Under what circumstances are organic solvents added to biocatalytic processes? [5]

b) What are the main issues involved in the design of such processes? [5]

c) Outline an experimental plan to evaluate the issues identified in (b). [13]

5.

The homogeneous, gas-phase reaction $A \rightarrow 3R$ follows first-order kinetics. For a feed volumetric flowrate of 4 $m^3\ h^{-1}$ of pure A, an experimental plug-flow reactor operating at constant temperature and pressure, having a length of 2 m and a diameter of 3 cm, achieves 60% conversion of A.

An industrial PFR, operating at the same temperature and pressure as the experimental reactor, will be used to process 320 $m^3\ h^{-1}$ of feed which contains 60% A and 40% inerts. Calculate the number of pipes (of length 2 m and diameter 3 cm) needed, if the conversion of A at the exit of the reactor is 85%. [25]

6.

The reaction between ethylene chlorhydrin and sodium bicarbonate to produce ethylene glycol is elementary with rate constant $k = 5.2\ dm^3\ mol^{-1}\ h^{-1}$ at 82 °C.

$$C_2H_4OHCl + NaHCO_3 \rightarrow C_2H_4(OH)_2 + NaCl + CO_2$$

We wish to construct a pilot plant to determine the economic feasibility of producing ethylene glycol from two available feeds, a 15 wt % aqueous solution of sodium bicarbonate and a 30 wt % aqueous solution of ethylene chlorhydrin.

a) What volume of a plug flow reactor (PFR) will produce 20 kg h^{-1} ethylene glycol at 95% conversion of a feed containing equimolar proportions of reactants, produced by intimately mixing appropriate quantities of the two feed streams? [15]

b) What size of a well mixed flow reactor (CSTR) is needed for the same feed, conversion and production rate as in part (a) above? [10]

Assume all operations at 82 °C, at which temperature the density of the mixed reacting fluid is 1.02 g cm^{-3}.

Additional data.

Relative Molar Mass of C_2H_4OHCl = 80.5

Relative Molar Mass of $NaHCO_3$ = 84

Relative Molar Mass of $C_2H_4(OH)_2$ = 62.1

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